Probe Needle for Testing Semiconductor Chips and Method for Producing Said Probe Needle

[0001] This application claims the benefit under 35 U.S.C. § 120 to PCT application PCT/DE02/03830, filed on October 11, 2002, entitled "Probe Needle for Testing Semiconductor Chips and Method for Producing Said Probe Needle" and published in English on May 1, 2003 as International Publication No. WO 03/035541 A2, which application is hereby incorporated herein by reference.

TECHNICAL FIELD

[0002] The invention pertains to a probe needle for testing semiconductor chips, one end of said probe needle being fixed in a holding element and the free end thereof comprising a contact tip. The invention also pertains to a method for manufacturing a probe needle for testing semiconductor chips, with several processing steps for forming the probe needle.

BACKGROUND

[0003] Semiconductor chips are tested individually or in wafer form. Contact surfaces, e.g., the bond pads, are electrically contacted on the chip and connected via a probe needle to a test circuit. Electronic test signals are applied to the circuit on the chip via this test circuit, and the response to these test signals is measured and evaluated. If behavior deviating from the desired function is determined, the measured chip is rejected as defective, or defect parameters for the subsequent correction of defects are determined.

[0004] In order to carry out the contact of the probe needle with the contact surfaces, the relative movement between the given probe needle and the corresponding contact surface and toward one another is necessary. This movement is generally designated as touchdown. The

probe needle is provided with a tip in order to improve the contact of the probe needle with the contact surface.

[0005] However, in practice, the tips oxidize after a number of touchdowns and exhibit deformation. This results in greater contact resistance with the contact surfaces. But high mechanical stability of the contact tips and low contact resistance are of crucial importance in semiconductor measuring technology.

[0006] In present practice, various cleaning methods for the contact tips, such as intermediate contacting of adhesive films or cleaning of wafers, are used to increase measurement reliability. However, conventional cleaning methods result in increased curvature of the contact tips. Also, an increase of the so-called overdrive or a double touchdown is possible for breaking up the oxide on the needle tip. However, this results in damage to the contact pad, which has disadvantages in subsequent process steps, such as wire bonding, or in further contact for measuring purposes.

[0007] The contact tips are damaged when making contact with the contact surfaces of the semiconductor chips. On the one hand, this takes place by scratching the contact tips on the contact surface, which is partially intentionally produced in order to decrease the contact resistance. On the other hand, material is also torn from the surface of the contact tip as a result of microweldings that occur when a test voltage is applied. This damage to the contact tip results in unreliable measurements, high maintenance costs, and low service life of the probe needles. In particular, when probe cards are used, the low service life of the probe needles contributes to an early failure of the cost-intensive probe cards.

[0008] The use of probe needles for testing semiconductor structures has long been known in the prior art and is described, e.g., in U.S. Patent No. 5,023,561 or in EP Patent No. 0 660 387

B1. These publications also concern the design of probe needles, particularly the shaping of the tips, but do not solve the basic problem.

SUMMARY OF THE INVENTION

[0009] In one aspect, the present invention increases the service life of probe needles. For example, in one embodiment, the probe needle, at least on the surface of the contact tip, is provided with a coating of a chemically inert, electrically conductive material that is hard relative to the material of the contact surfaces of the semiconductor chips. Microwelding of the contact surface can be avoided by means of this coating. Also, the hardness reduces the mechanical wear of the contact tips. Thus, overall, such a coating increases the service life of the probe needle. Adverse effects on the remaining manufacturing process of the semiconductor chips are avoided because the coating material is chemically inert.

[0010] An embodiment of the invention provides for the entire surface of the probe needle or its main part to be coated. The application of the coating to other surface areas of the probe needle besides the contact tip has no disadvantageous influence on the functionality as a result of the electrical conductivity. On the contrary, this has advantages in the manufacturing process because the contact tips are not subjected to a special treatment and the remaining parts of the probe needle need not be covered; instead, the entire probe needle can be coated.

[0011] A particularly advantageous embodiment of the invention provides that the coating consist of titanium nitride. On the one hand, titanium nitride precisely satisfies the necessary criteria. On the other hand, it is a well-known coating material in semiconductor fabrication. Thus, the coatings can also be formed at low cost by the semiconductor manufacturer itself.

[0012] It can be advantageous in this connection to arrange a seed or adhesive layer of titanium beneath the titanium nitride layer, i.e., between the surface of the probe needle and the titanium nitride layer. On the one hand, this facilitates the growth of the titanium nitride layer on

the substrate material of the probe needle during manufacture, which usually consists of aluminum, palladium or tungsten, and on the other hand, improves adhesion.

[0013] The preferred embodiment also solves problems in terms of the method, in that the probe needle is coated at least in the area of its contact tip, but preferably completely, with a chemically inert, electrically conductive material that is hard relative to the material of the surfaces of the semiconductor chips to be contacted. Such a coating does not constitute any significant expense in the manufacturing process of the probe needles. It can, however, significantly reduce the mechanical and electrical wear on the probe needles during use, thereby increasing their service life.

[0014] A particularly advantageous embodiment of the method of the invention provides that the probe needle be coated with titanium nitride. Semiconductor wafers are also coated with this material during the fabrication process. On the one hand, this makes coating possible by a simple means which may even be available to the user of the probe needle. On the other hand, no materials outside the technology need be used, which prevents disadvantageous effects on the rest of the technology.

[0015] In order to facilitate the growth of the titanium nitride layer and to improve the adhesiveness of the substrate material of the probe needle, it is advantageous to coat the probe needle with titanium prior to the coating with titanium nitride. Titanium nitride can then be coated.

[0016] The method of physical vapor deposition (PVD) is an advantageous method known in the field of semiconductor fabrication technology, for which reason it is advantageous if the probe needle is coated using a PVD method, preferably with a reactive magnetron sputtering method.

[0017] It is advantageous if this coating takes place from a target of titanium with the addition of a reactive gas mixture of argon and nitrogen.

[0018] If a seed or adhesive layer consisting of titanium is to be produced beneath the layer of titanium nitride, it is advantageous for a favorable shaping if the coating with titanium and titanium nitride is carried out in situ since the coating process can then take place in a processing chamber without having to be interrupted. A coating proved to be especially suitable is one in which the stoichiometric ratio of titanium (Ti) to nitrogen (N) is Ti:N = 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0020] Figure 1 is an exemplary probe needle prior to coating;

[0021] Figure 2 is a schematic diagram of the probe needle being coated; and

[0022] Figure 3 is an exemplary probe needle subsequent to coating.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0023] The making and using of the presently preferred embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

[0024] The invention will be explained in detail in the following with reference made to an embodiment example. The associated drawings show the sequence of the method and a coated probe needle in a schematic fashion.

[0025] Figures 1-3 illustrate the formation of a coating layer on the end of a contact tip 3 in accordance with a preferred embodiment of the present invention. Referring first to Figure 1, a probe needle 1, manufactured during prior processing steps, is fastened in a holding element (not shown), which can be a probe card. The probe needle is provided on its free end 2 with contact tip 3.

[0026] As shown in Figure 2, probe needle 1 is introduced into vacuum processing chamber 4 in which a magnetron (not shown) with a titanium target 5 is arranged. Probe needle 1 is introduced into vacuum processing chamber 4 in such a way that its contact tip 3 faces in the direction of target 5, that is, opposite target 5.

[0027] After the evacuation of vacuum processing chamber 4, target material, that is, titanium as seed and adhesive layer, is applied onto probe needle 1 by the plasma produced in the chamber. A mixture of reactive gas, e.g., argon and nitrogen is introduced, as a result of which

titanium nitride is produced in the plasma and is deposited onto the probe needle as coating 6. The coated tip 3 is shown in Figure 3.

[0028] This coating 6 is very hard relative to the material of the contact surfaces (not shown) of the semiconductor chip to be contacted. It is also electrically conductive and chemically inert. As a result, the wear on probe needle 1 can be significantly reduced, which increases its service life.

[0029] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.